Anatomy and Physiology: The Nervous System

CHAPTER 1

Understanding the anatomy and physiology of the nervous system is essential as it forms the basis for comprehending various health conditions, conducting assessments and delivering quality patient care. Care providers have contact with a number of patients who are living with neurological disorders who may be at home following acute neurosurgical interventions or with long-term neurological conditions or being cared for in a hospital setting as a result of a brain injury.

The nervous system is one of the main communicating and control systems within the body. It works closely with the endocrine system to control many body functions. The nervous system provides a rapid and short-acting response and the endocrine system provides a slower but often more sustained response. The two systems work together to maintain homeostasis (McErlean and Migliozzi 2020).

The nervous system interacts with all other body systems. This is a large and complex system. In order to enable understanding of the nervous system, it has to be divided into smaller functional and anatomical parts. This chapter outlines the divisions of the nervous system; it discusses the structure and function of the nervous system and how it influences other structures of the body.

ORGANISATION OF THE NERVOUS SYSTEM

The nervous system is divided into two parts: the central nervous system and the peripheral nervous system. The central nervous system is made up of the brain and spinal cord, which is the control and integration centre for many body functions. The peripheral nervous system carries sensory information to the central nervous system and motor information out of the central nervous system. The direction of information flow to and from the nervous system is shown in Figure 1.1.

SENSORY DIVISION OF THE PERIPHERAL NERVOUS SYSTEM

Sensory information (called stimuli) is gathered from inside and outside of the body. This sensory input is delivered to the central nervous system via the peripheral nerves. Sensory nerve fibres are also called afferent fibres. Sensory information always travels from the peripheral nervous system towards the central nervous system. There are many kinds of sensory information, including pain, pressure, temperature, chemical levels and more. McErlean and Migliozzi (2020) consider the maintenance of body temperature; it is important that body temperature is maintained between 36.5 and 37.5 °C. Temperature receptors in the skin, known as thermoreceptors, detect changes in temperature, as temperature changes have the potential to cause damage to cells and tissues; this information has to be relayed to the central nervous system and if needed, it is acted upon.

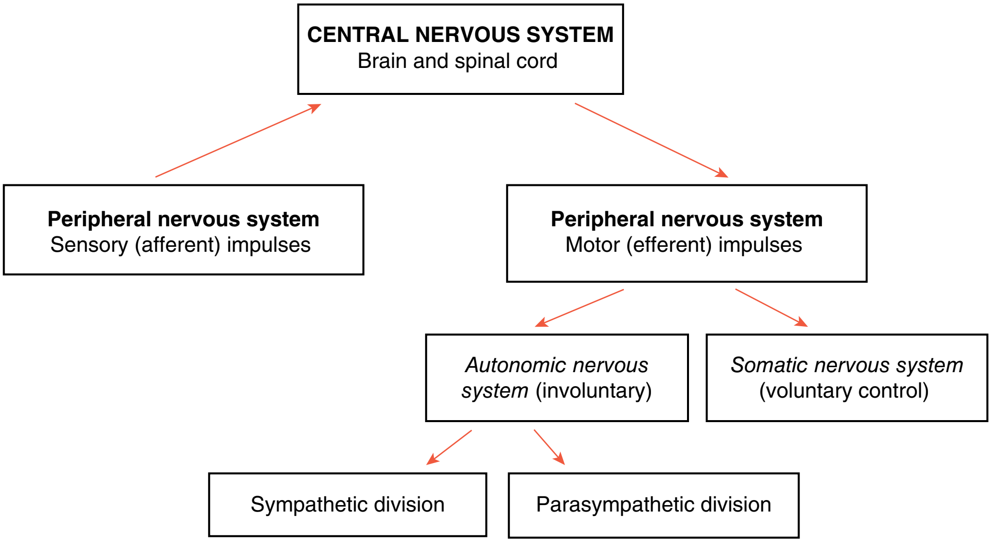

FIGURE 1.1 Organisation of the nervous system

CENTRAL NERVOUS SYSTEM

The central nervous system consists of the brain and spinal cord. The central nervous system processes and integrates sensory information. The information received has to be interpreted, which can either be stored to be dealt with later or can be acted upon immediately with one or more motor responses. For example, the sensation of a temperature change would be received and interpreted by the hypothalamus (a structure of the central nervous system) and an appropriate action would be initiated.

MOTOR DIVISION OF THE PERIPHERAL NERVOUS SYSTEM

The motor division of the peripheral nervous system always carries impulses away from the central nervous system, usually to effector organs (these respond to signals from the nervous system or hormonal system by producing a specific effect). Motor nerve fibres are also called efferent fibres. There are two types of motor information: motor information to the somatic nervous system or to the autonomic nervous system.

SOMATIC NERVOUS SYSTEM

The somatic nervous system is under voluntary control and the effector (tissue or organ responding to instruction from the central nervous system) is skeletal (voluntary) muscle.

The central nervous system's response to sensory information may be to activate the somatic nervous system, prompting a voluntary response that involves skeletal muscle movement. For example, if an increase in temperature is detected, then it may require the removal of a coat or the opening of a window. This is the motor response that involves the somatic nervous system. This is a voluntary activity the person has chosen to take.

AUTONOMIC NERVOUS SYSTEM

The central nervous system's response to sensory information may be to activate the autonomic nervous system. This would lead to an involuntary action. The autonomic nervous system is responsible for involuntary motor responses. The effector may be smooth or cardiac muscle (they are both involuntary muscles) or a gland.

In the example of increased temperature, the involuntary response is to lose heat through the skin–so warm blood is directed to the skin when peripheral blood vessels vasodilate. Vasodilatation is an example of an involuntary autonomic nervous system response. The individual cannot control this response.

The autonomic nervous system is further divided into the sympathetic (fight or flight) and the parasympathetic (rest and digest) divisions. A fine balance between both of these divisions is required for the maintenance of homeostasis.

Neurones The functional unit of the nervous system is the neurone or nerve cell. It has several features in common with other cells, including a nucleus and mitochondria. As a result of its vital role, it is well protected and has some specialist modifications. Two specialist characteristics of neurones are:

- Irritability, in response to a stimulus – the ability to initiate a nerve impulse.
- Conductivity – the ability to conduct an impulse.

Neurones comprise an axon, dendrites and a cell body. Their function is to transmit nerve impulses. Nerve impulses only travel in one direction: from the receptive area – the dendrites – to the cell body and down the length of the axon (see Figure 1.2).

Axons bundled together are known as nerves. Neurones depend on a constant supply of oxygen and glucose. Once the neurones of the brain and spinal cord have matured after birth, they are not replaced or regenerated if they become damaged. Peripheral neurones can regenerate if the cell body is not damaged and the alignment of the neurone has not been disrupted.

Dendrites These are short branching processes that receive information and conduct it towards the cell body. Their branching processes provide a large surface area for this function. In sensory neurones, dendrites may form a part of the sensory receptors, and in motor neurones, they can form part of the synapse between one neurone and the next.

Cell Body Most neurone cell bodies are located inside the central nervous system, forming the grey matter. When clusters of cell bodies are grouped together in the central nervous system, they are known as nuclei. Cell bodies located in the peripheral nervous system are called ganglia.

Axons Each neurone has only one axon conducting information away from the cell body. The axon can branch to form an axon collateral and will also branch at its terminal into many axon terminals (see Figure 1.1). The axon delivers the impulse to another neurone or a gland or a muscle. Axon length can vary significantly from very short to 100 cm long (Marieb and Hoehn 2019).

Myelin Sheath Peripheral nerve axons and long or large axons are covered in a myelin sheath, a fatty material protecting the neurone and electrically insulating it, speeding up

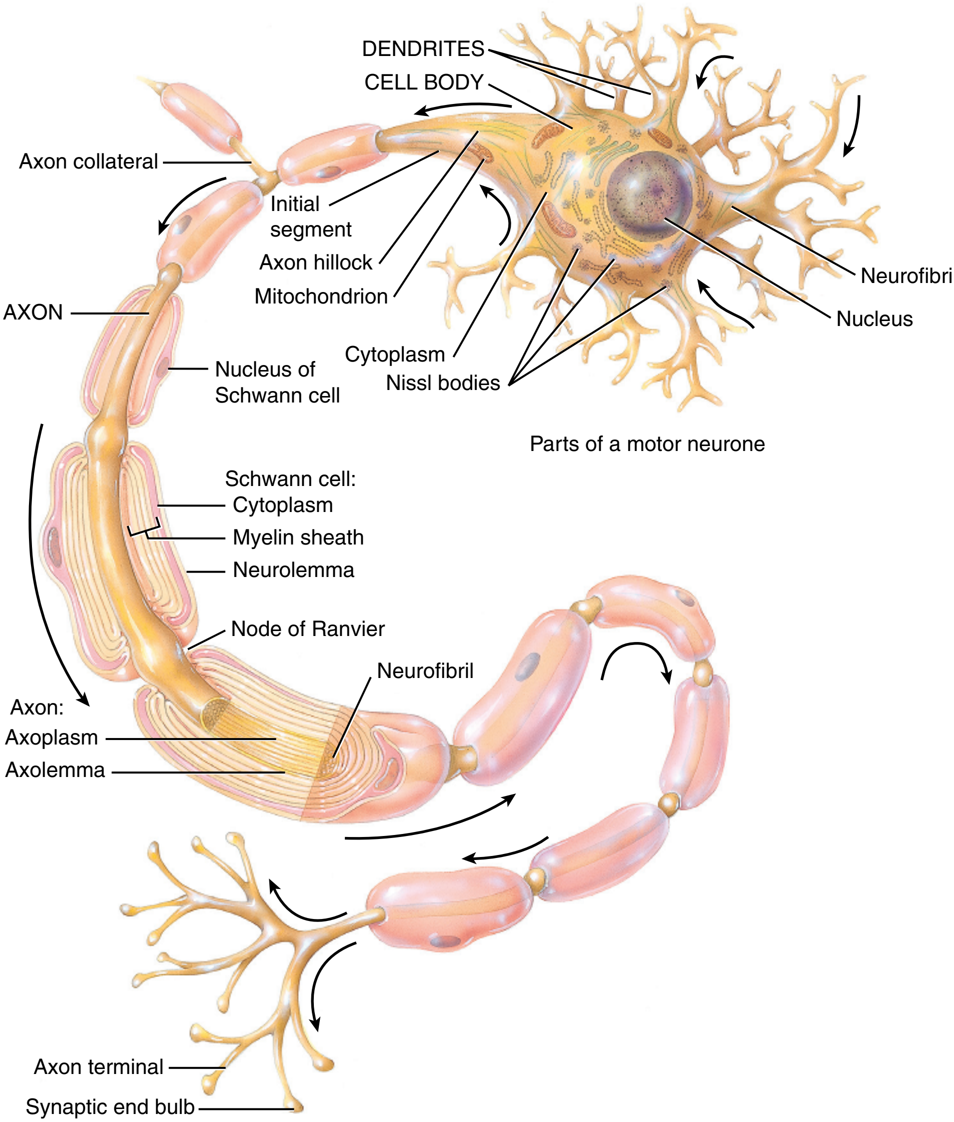

FIGURE 1.2 Motor neurone

impulse transmission. Within the peripheral nervous system, Schwann cells are wrapped in layers around the neurone from the myelin sheath. The outermost part of the Schwann cell is its plasma membrane, which is called the neurilemma. There is a regular gap (about 1 mm) between adjacent Schwann cells. The gaps are called the nodes of Ranvier. Collateral axons can occur at the node (see Figure 1.2). Some nerve fibres are unmyelinated, which makes nerve impulse transmission significantly slower.

Sensory (Afferent) Nerves Dendrites of sensory neurones are often sensory receptors; when stimulated, the impulse generated travels towards the spinal cord and brain. There are different types of sensory receptors:

- Special senses.
- Somatic sensory receptors, located in the skin, such as touch, temperature and pain.
- Autonomic nervous system receptors, located throughout the body, such as baroreceptors monitoring blood pressure, chemoreceptors monitoring blood pH and visceral pain receptors.
- Proprioceptors, monitoring muscle movement, stretch and pain.

Motor (Efferent) Nerves Information from the central nervous system is delivered to the peripheral nervous system via the motor nerves. Information transmitted through a voluntary somatic nerve can cause skeletal muscle contraction or the information may be autonomic in nature, not under voluntary control, and may lead to smooth muscle contraction or release of the products of a gland.

The Action Potential The nervous system is a vast communicating network sending information from the internal and external environment to the central nervous system and from the central nervous system to the muscles and glands. The way the functional unit, the neurone, achieves this is by the generation and conduction of impulses or action potentials.

The action potential is a brief electrical signal that travels along the membrane of a nerve cell (neurone) or a muscle cell. In the context of the brain, neurones use action potentials to transmit information.

NEUROTRANSMITTERS

Neurones do not come into contact with one another. Where one neurone ends and another begins, there is a space called the synapse. In order for communication to occur between neurones or between the neurone and a muscle or gland, a chemical messenger, a neurotransmitter is secreted by the neurone into the extracellular space at the synapse. Those effector cells or neurones close to the neurotransmitter will either be stimulated or inhibited by the neurotransmitter, depending upon which neurotransmitter is secreted. The action of the neurotransmitter is short-lived. Any neurotransmitter not used is absorbed by the neurone to be recycled and used again or deactivated by enzymes. Examples of neurotransmitters:

- Acetylcholine, released within the central nervous system and at the neuromuscular junction.
- Norepinephrine, released within the central nervous system and at autonomic nervous system synapses.
- Dopamine, released within the central nervous system and at autonomic nervous system synapses.

NEUROGLIA

These are cells that support neurones (see Figure 1.3), and they are more numerous than neurones. Within the central nervous system, the neuroglial cells account for more than half of the weight of the brain (Marieb and Hoehn 2019). Neuroglia can multiply to support the neurones. Nervous system tumours often originate from neuroglia because of this (neuroglioma).

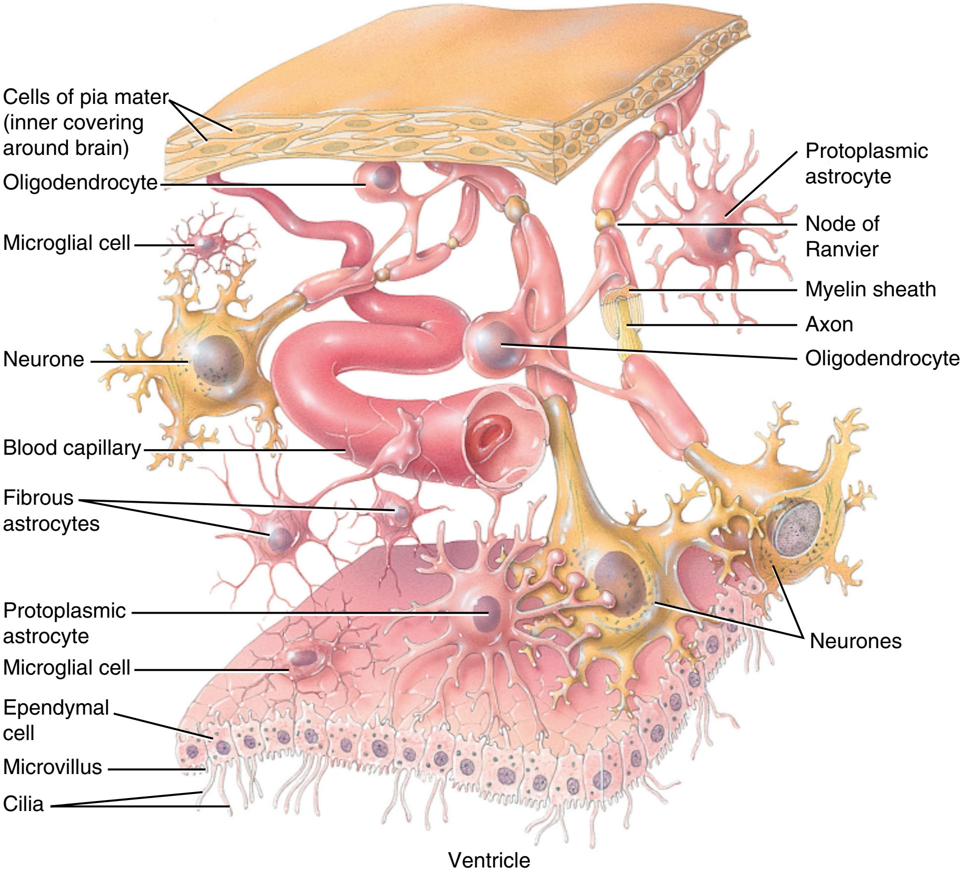

FIGURE 1.3 Neuroglia

Two types of neuroglia have been identified within the peripheral nervous system:

- Schwann cells, responsible for forming the myelin sheath.
- Satellite cells, whose function is not known.

Within the central nervous system, four types of neuroglial cell have been identified:

- Astrocytes, star-shaped cells occurring in large quantities between neurones and blood vessels, supporting and anchoring them to each other. They help form the blood–brain barrier. This gives the neurones an extra layer of protection from any toxic substances within the blood.
- Microglia lie close to neurones and can move closer if needed to fulfil their function as nervous system macrophages. They are pathogens or cell debris that have been phagocytosed.
- Oligodendrocytes, located close to myelinated neurones. Help form and maintain the myelin sheath.
- Ependymal cells, often ciliated, are found lining cavities, such as the spinal cord or ventricles of the brain. Their role is to circulate cerebrospinal fluid (CSF).

MENINGES

Nervous tissue is easily damaged by pressure and therefore needs to be protected. Hair, skin and bone offer an outer layer of protection. Adjacent to the nervous tissue are the meninges (see Figure 1.4). The meninges cover the delicate nervous tissue, providing further protection. They also protect the blood vessels that serve the nervous tissue and contain CSF. The meninges are made up of three connective tissue layers:

1. Dura mater
2. Arachnoid mater
3. Pia mater

THE CEREBROSPINAL FLUID

The CSF is produced by the choroid plexus located within the ventricles of the brain (see Figure 1.5). Approximately 150 mL of CSF circulates around the brain, in the ventricles and around the spinal cord. The entire volume of CSF is replaced approximately every six to eight hours. As a cushion to the brain, it protects it from damage, maintains a uniform pressure between the brain and spinal cord and plays a small role in fluid and waste exchange between the brain and spinal cord.

BRAIN

One of the largest and most complex organs in the body. The brain is responsible for the integration of sensory information (for example, it interprets the senses); it also directs motor responses (the initiator of body movement and controller of behaviour) and is the centre of learning.

The brain weighs around 1400–1600 g (Marieb and Hoehn 2019), protected inside a bony shell (the cranium or skull) and washed by protective fluid (CSF). It is the source of all those qualities that define us as humans (Figure 1.6).

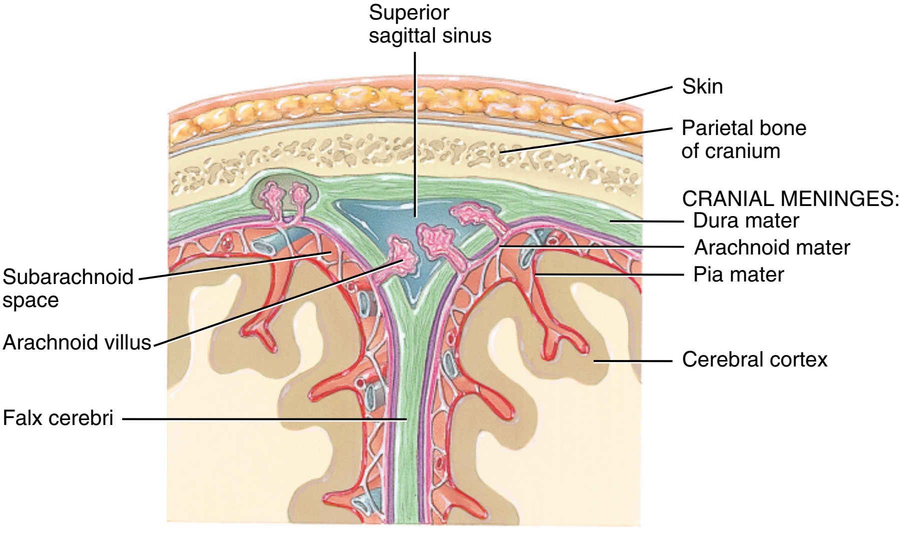

FIGURE 1.4 The meninges

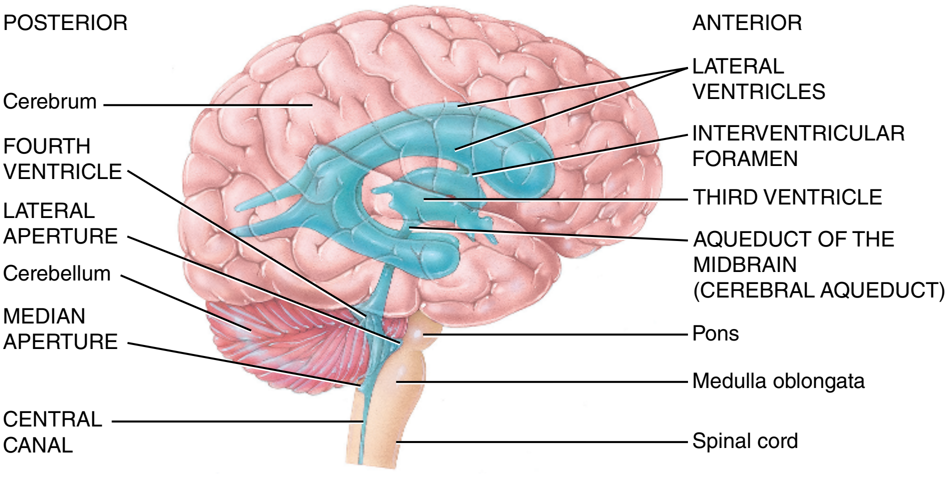

FIGURE 1.5 The ventricles

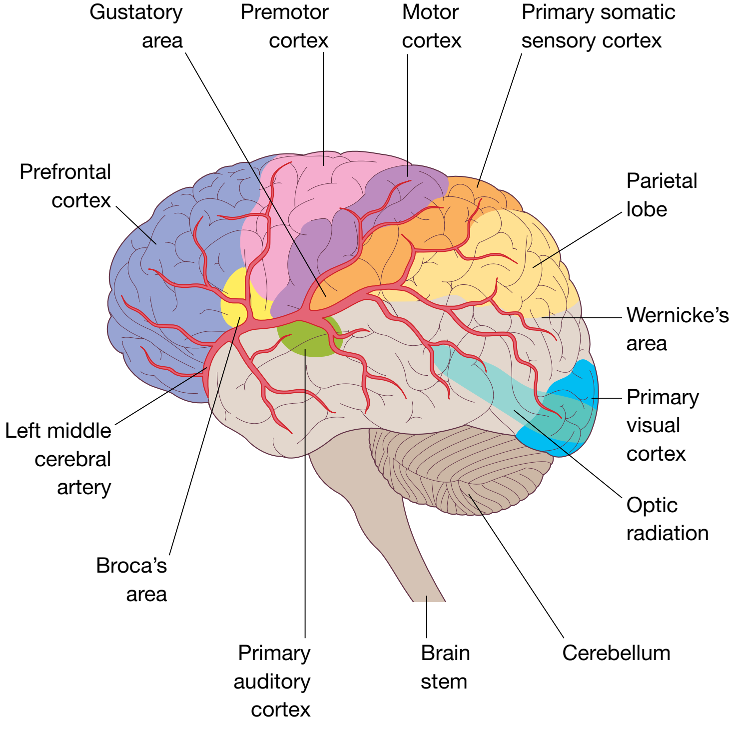

FIGURE 1.6 The brain

The brain receives 15% of the cardiac output. It has a system of autoregulation, ensuring its blood supply is constant regardless of positional changes. Most of the expansion comes from the cerebral cortex, a convoluted layer of neural tissue covering the surface. The frontal lobes are particularly expanded and are involved in executive functions, such as self-control, planning, reasoning and abstract thought.

Brainstem The structures forming the brainstem are involved in numerous activities essential for life. The brainstem is associated with the cranial nerves.

- Midbrain: conduction pathway connecting the cerebrum with the lower brain structures and spinal cord.
- Pons: also a conduction pathway that communicates with the cerebellum. The pons works with the medulla oblongata, controlling depth and rate of respiration.
- Medulla oblongata: a relay station for sensory nerves going to the cerebrum (see Figure 1.7). It contains autonomic centres, for example, the cardiac centre, respiratory centre, vasomotor centre and coughing, sneezing and vomiting centres. The medulla is also the site of decussation of the pyramidal tracts – this means that the right side of the body is controlled by the left cerebral hemisphere and vice versa.

Diencephalon The diencephalon provides a functional link between the cerebral hemispheres and the rest of the central nervous system. It contains three paired structures: the thalamus, hypothalamus and epithalamus. Each component of the diencephalon has specialised functions integral to life.

Thalamus The thalamus acts as a relay station for sensory impulses going to the cerebral cortex for integration and motor impulses entering and leaving the cerebral hemispheres. It also plays a role in memory.

Hypothalamus The hypothalamus is closely associated with the pituitary gland, and produces two hormones: antidiuretic hormone and oxytocin. It is the chief autonomic integration centre and is part of the limbic system (the emotional brain).

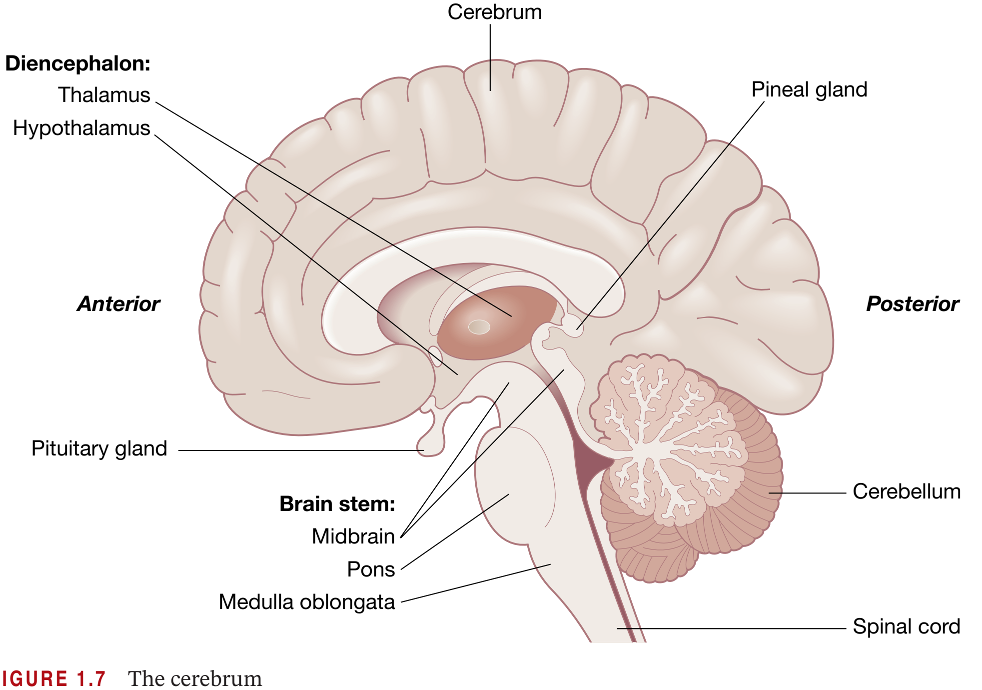

FIGURE 1.7 The cerebrum

Epithalamus The epithalamus is a small structure connected to the pineal gland, which secretes the hormone melatonin. Melatonin plays a key role in regulating the sleep-wake cycle, also known as the circadian rhythm.

Brainstem The brainstem regulates vital cardiac and respiratory functions and acts as a vehicle for sensory information. Structures forming the brainstem are involved in a range of activities essential for life. The structures of the brainstem include the midbrain, pons and medulla oblongata.

Midbrain The midbrain contains nuclei that deal with auditory and visual information and reflexes. It also maintains consciousness and provides a conduction pathway connecting the cerebrum with the lower brain structures and spinal cord.

Pons The pons connects and communicates with the cerebellum. It works with the medulla oblongata to control the depth and rate of respiration and contains nuclei that function in visceral and somatic motor control.

Medulla Oblongata The medulla oblongata is a relay station for sensory nerves going to the cerebrum. The medulla contains autonomic centres such as the cardiac centre, respiratory centre, vasomotor centre and coughing, sneezing and vomiting centres. The medulla is also the site of decussation of the pyramidal tract; this means that the right side of the body is controlled by the left cerebral hemisphere and vice versa.

Cerebellum The cerebellum coordinates voluntary muscle movement, balance and posture. It ensures muscle movements are smooth, coordinated and precise (see Figure 1.8).

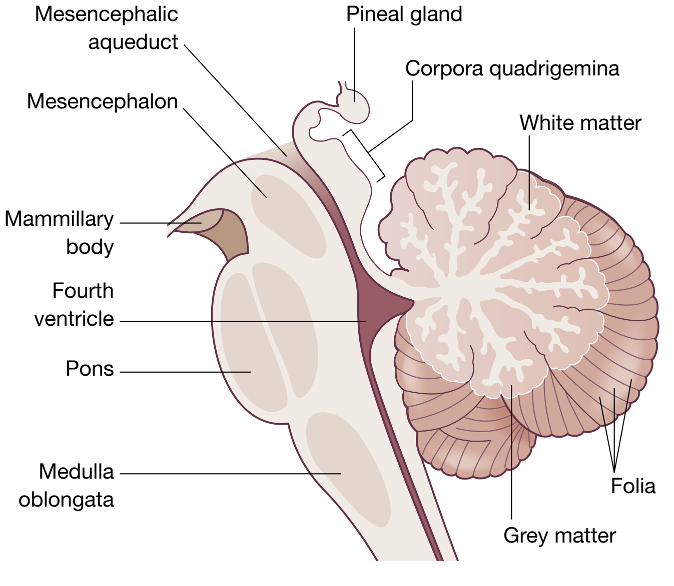

FIGURE 1.8 The cerebellum

The Limbic System and the Reticular Formation These are functional systems consisting of networks of neurones that are distributed across multiple anatomical structures (see Figure 1.9). The limbic system is located close to the cerebrum and the diencephalon. It is known as the emotional brain and is responsible for the interpretation of facial expressions helping identify fear and danger. The reticular formation is a functional system located in the core of the brainstem and consists of a collection of neurones that have several functions:

- Contains the reticular activating system responsible for alertness.
- Filters or blocks repetitive stimuli, such as background noise.
- Regulates skeletal muscle activity.
- Coordinates visceral activity controlled by the autonomic nervous system.

THE BLOOD SUPPLY TO THE BRAIN

The blood supply to the brain is a critical aspect of maintaining its function, as the brain is highly sensitive to changes in blood flow, and it requires a constant supply of oxygen and nutrients. The blood supply to the brain is provided by two pairs of arteries: the internal carotid arteries and the vertebral arteries. These arteries, along with their branches, form the cerebral arterial circle (circle of Willis), which helps ensure a continuous supply of blood to the brain even if one of the main arteries is compromised.

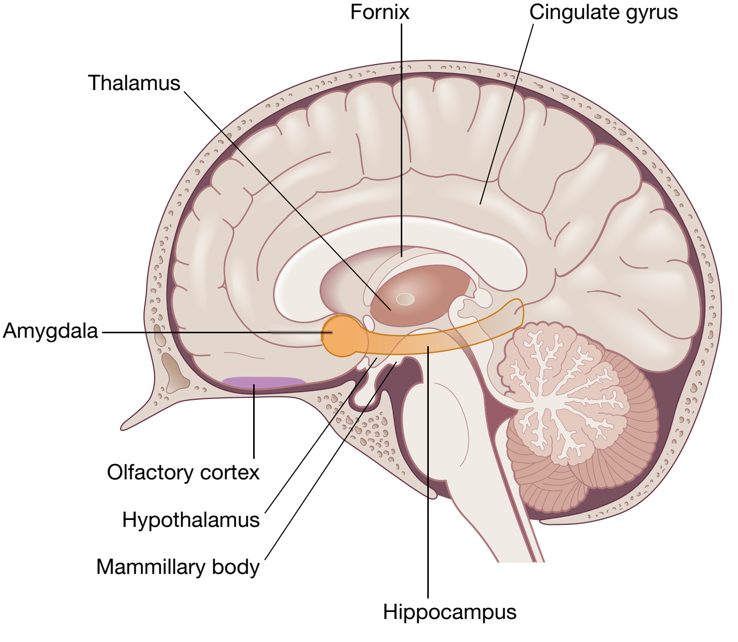

FIGURE 1.9 The limbic system

CIRCLE OF WILLIS

The circle of Willis (called the circulus arteriosus cerebri) constitutes an interconnected network of arteries (Figure 1.10), which is located at the base of the brain. It is a junction of several important arteries, helping blood flow from both the front and back sections of the brain.

The circle of Willis encircles the stalk of the pituitary gland, providing important communications between the blood supplies of major divisions of the brain. The circle of Willis is formed when the internal carotid artery enters the cranial cavity on both sides and then divides into the anterior cerebral and middle cerebral arteries. The anterior cerebral arteries are then united by an anterior communicating artery. These connections form the anterior half (anterior circulation) of the circle of Willis.

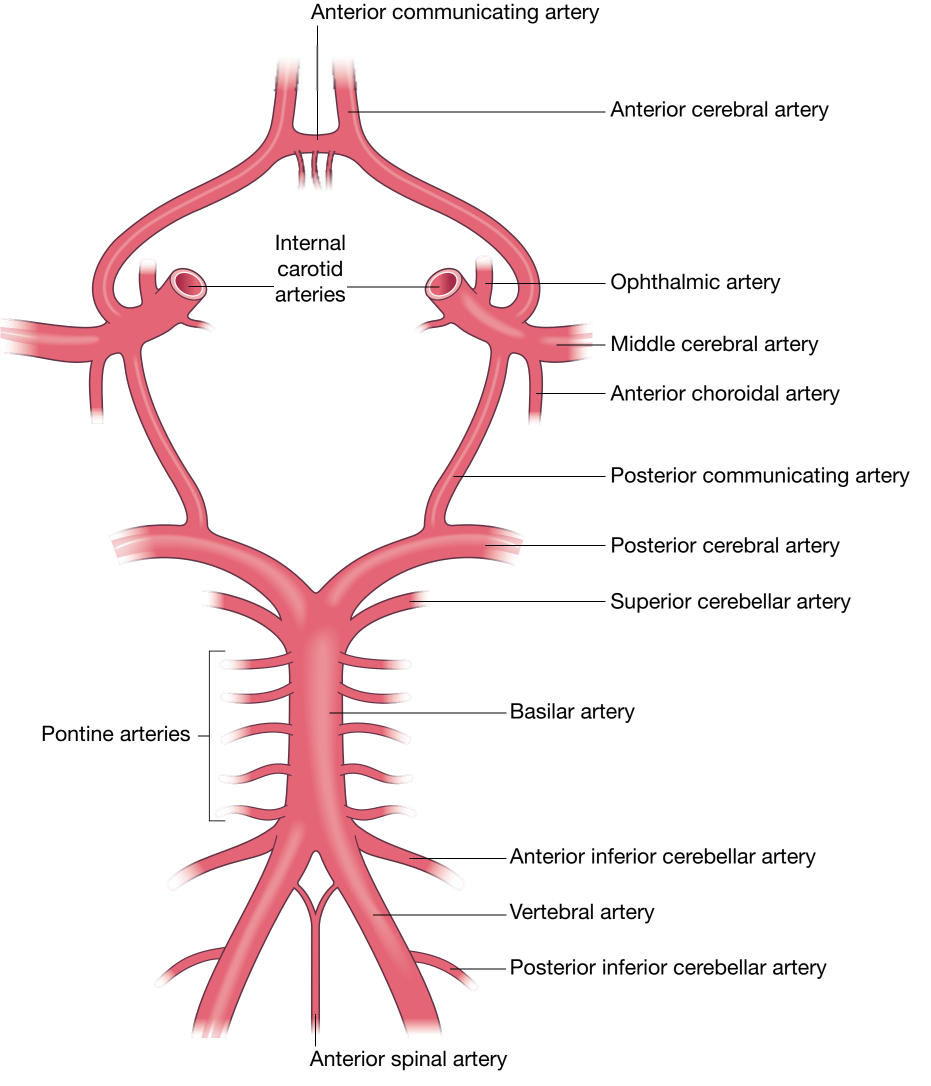

FIGURE 1.10 The circle of Willis

Posteriorly, the basilar artery, formed by the left and right vertebral arteries, branches into a left and right posterior cerebral artery, forming the posterior circulation. The posterior communicating arteries complete the circle of Willis by joining the internal carotid system anteriorly via the posterior communicating arteries.

Although in an adult the brain represents only 2% of total body weight, it uses 20% of oxygen and glucose even when at rest. When activities in a certain area of the brain increase, blood flow to that region will also increase. Even a momentary slowing of blood flow to the brain can result in unconsciousness.

Further decreases in blood flow, for two minutes, can lead to impaired neuronal function. If the blood flow is restricted for four minutes or more, this may lead to permanent brain damage. As the brain does not store glucose, it is essential that there be a continuous supply of glucose to the brain.

FUNCTION OF THE CIRCLE OF WILLIS

The circle of Willis provides numerous paths for the oxygenated blood to supply the brain. If any of the principal suppliers of oxygenated blood (i.e. the vertebral and internal carotid arteries) are constricted by physical pressure, occluded by disease or interrupted by injury, this could result in serious complications. The goal of any treatment required would be to reduce the risk of stroke. Treatment options vary according to the severity of the arterial narrowing and whether the person is experiencing stroke-like symptoms or not.

THE BLOOD–BRAIN BARRIER

The blood–brain barrier is a highly selective semi-permeable border; that is, it allows some materials to cross the barrier but will prevent others from crossing. In most parts of the body, the smallest blood vessels, called the capillaries, are lined with endothelial cells. Endothelial tissue has small spaces between each individual cell so that substances can move readily between the inside and outside of the vessel. However, in the brain, the endothelial cells fit tightly together (they are wedged together) and substances are not able to pass out of the bloodstream (Figure 1.11), providing an endothelial tight junction. Some molecules, for example, glucose, are transported out of the blood by special methods.

Glial cells (astrocytes) form a layer around brain blood vessels and may be important in the development of the blood–brain barrier. Astrocytes may also be responsible for transporting ions from the brain to the blood.

FUNCTION OF THE BLOOD–BRAIN BARRIER

The blood–brain barrier protects cells of the brain from harmful substances and pathogens by preventing the passage of many substances from the blood into the brain tissue. It also provides a constant environment for the brain and protects it from hormones and neurotransmitters in the rest of the body.

The purpose of the blood–brain barrier is to protect against circulating toxins or pathogens that may cause brain infections, while at the same time allowing vital nutrients to reach the brain. It has a protective function.

A few water-soluble substances, such as glucose, cross the blood–brain barrier by active transport. Other substances, for example, urea and most ions, cross the barrier very slowly. Protein and most antibiotics do not cross the barrier, preventing them from entering brain

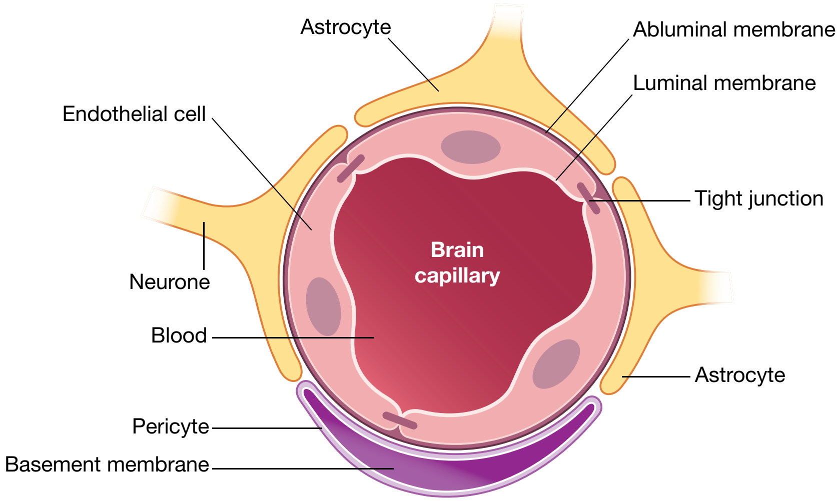

FIGURE 1.11 The blood–brain barrier

tissue. However, lipid-soluble substances such as oxygen, carbon dioxide, alcohol and most anaesthetic drugs do cross the blood–brain barrier easily.

The blood–brain barrier can be broken down by hypertension (high blood pressure). Exposure to microwaves or radiation, infection and injury to the brain such as trauma, inflammation and ischaemia can all open the blood–brain barrier. The barrier is not considered to affect the movement of inflammatory cells into the central nervous system; activated lymphocytes can enter the normal central nervous system.

Disruptions in the blood supply to the brain, such as ischaemia (reduced blood flow) or haemorrhage (bleeding), can lead to serious neurological consequences, including stroke. Understanding the anatomy of the blood vessels supplying the brain is crucial for diagnosing and managing conditions affecting cerebral circulation.

THE PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system includes all tissues lying outside the central nervous system:

- Cranial nerves
- Spinal nerves
- Spinal cord
- Autonomic nervous system

The peripheral nervous system is subdivided into the efferent or motor system and the afferent or sensory system. The somatic sensory system serves the skeletal muscles, joints, tendons and skin and includes the senses of vision, hearing, smell and taste (Logenbaker 2019). The internal organs of the body are supplied by the visceral sensory system. Both somatic and visceral sensory systems take information from peripheral sensory receptors towards the central nervous system.

Commands from the central nervous system to the skeletal muscles are carried by the somatic motor system. The autonomic motor system predominantly regulates the activity of smooth and cardiac muscles and glands (Logenbaker 2019).

CRANIAL NERVES

There are 12 pairs of cranial nerves emerging from the brain, supplying various structures, most of which are associated with the head and neck. Figure 1.12 provides an overview of the location and function of the cranial nerves.

The 12 pairs of cranial nerves have different functions: some are sensory nerves (i.e. contain sensory fibres), some are motor nerves (i.e. contain only motor fibres) and some are mixed nerves (i.e. contain both sensory and motor nerves). Table 1.1 provides a summary of the cranial nerves, their different components and function.

SPINAL CORD

The average adult spinal cord (see Figure 1.13) is between 42 and 45 cm long and extends from the medulla oblongata (lower part of the brain) to the upper part of the second lumbar vertebra. The spinal cord is enclosed within the vertebral canal, which forms a protective ring of bone around the cord. Other protective coverings include the spinal meninges, which are three layers of connective tissue coverings that extend around the spinal cord. The spinal meninges consist of:

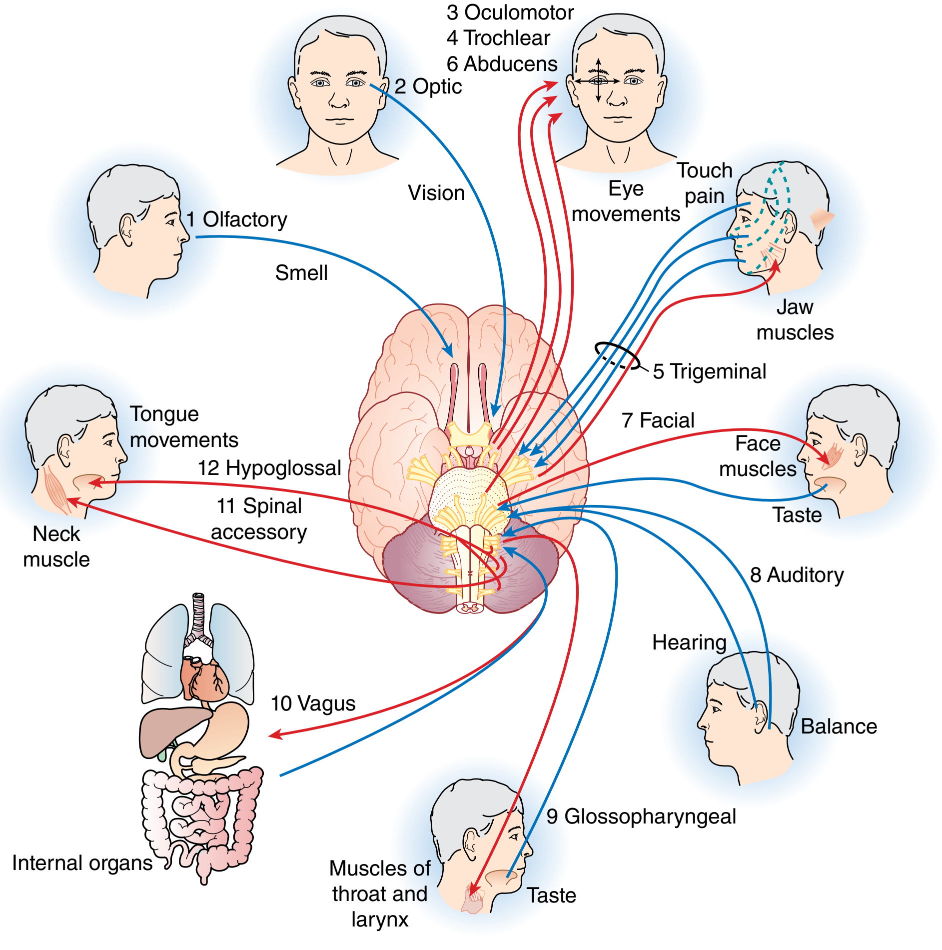

FIGURE 1.12 Functions of cranial nerves

Table 1.1 The cranial nerves

Number	Name	Components	Location/function
I	Olfactory	Sensory	Olfactory receptors for sense of smell
II	Optic	Sensory	Retina (sight)
III	Oculomotor	Motor	Eye muscles (including eyelids and lens, pupil)
IV	Trochlear	Motor	Eye muscles
V	Trigeminal	Sensory and motor	Teeth, eyes, skin, tongue for sensation of touch, pain and temperature
VI	Abducens	Motor	Jaw muscles (chewing)
			Eye muscles
VII	Facial	Sensory and motor	Taste buds
			Facial muscles, tears and salivary glands
VIII	Vestibulocochlear	Sensory	Inner ear (hearing and balance)
IX	Glossopharyngeal	Sensory and motor	Pharyngeal muscles (swallowing)
X	Vagus	Sensory and motor	Internal organs
XI	Spinal accessory	Motor	Neck and back muscles
XII	Hypoglossal	Motor	Tongue muscles

- The pia mater – innermost layer.
- The arachnoid mater – middle layer.
- The dura mater – outermost layer, consisting of a dense, irregular connective tissue.

The spinal cord consists of a central canal and grey and white matter. The central canal and the spinal meninges contain CSF. The grey matter is made up predominantly of cell bodies and their dendrites, the whiter areas consist of the axons of neurones, which carry signals up and down the cord via ascending and descending tracts. These tracts cross as they enter and exit the brain, explaining why the right side of the brain controls the left side of the body and the left side of the brain controls the right side of the body.

FUNCTIONS OF THE SPINAL CORD

The spinal cord provides a means of communication between the brain and the peripheral nerves leaving the spinal cord (Logenbaker 2019) and has two major functions in maintaining homeostasis:

- The tracts of the white matter carry sensory impulses to the brain and motor impulses from the brain to skeletal muscles and other effector muscles.
- The grey matter of the spinal cord is a site for integration of reflexes, which is a rapid, involuntary action in relation to a particular stimulus.

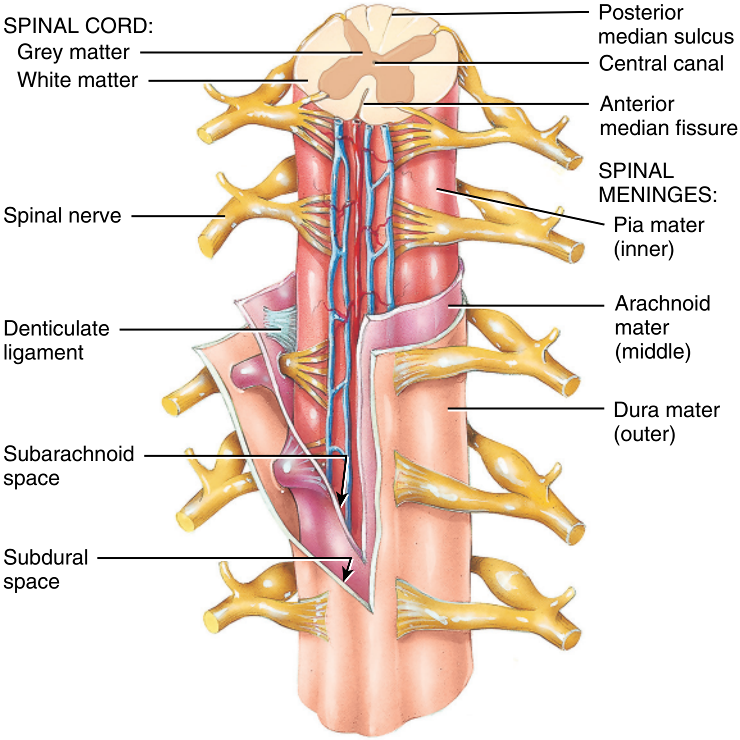

FIGURE 1.13 The spinal cord

SPINAL NERVES

There are 31 pairs of spinal nerves attached to the spinal cord, which are named and numbered according to the region and level of the vertebral column from which they emerge (Figure 1.14).

Each nerve innervates a group of muscles (myotome) and an area of skin (dermatome). Most also innervate some of the thoracic and abdominal organs.

The spinal nerves provide the paths of communication between the spinal cord and specific regions of the body as they connect the central nervous system to sensory receptors, muscles and glands in all the parts of the body. A typical spinal nerve has two connections to the spinal cord – a posterior root and an anterior root, which unite to form a spinal nerve at the intervertebral foramen. A spinal nerve is an example of a mixed nerve as it contains both sensory (posterior root) and motor (anterior root) nerves.

THE AUTONOMIC NERVOUS SYSTEM

The autonomic nervous system plays a key role in the maintenance of homeostasis by regulating the body's automatic, involuntary functions. In common with the rest of the nervous system, it consists of neurones, neuroglia and other connective tissues. However, its structure is unique, in that it is divided into two: namely, the sympathetic division and the parasympathetic division.

These two divisions have several common features (Logenbaker 2019). They:

- Innervate all internal organs.
- Utilise two motor neurones and one ganglion to transmit an action potential.
- Function automatically and usually in an involuntary manner.

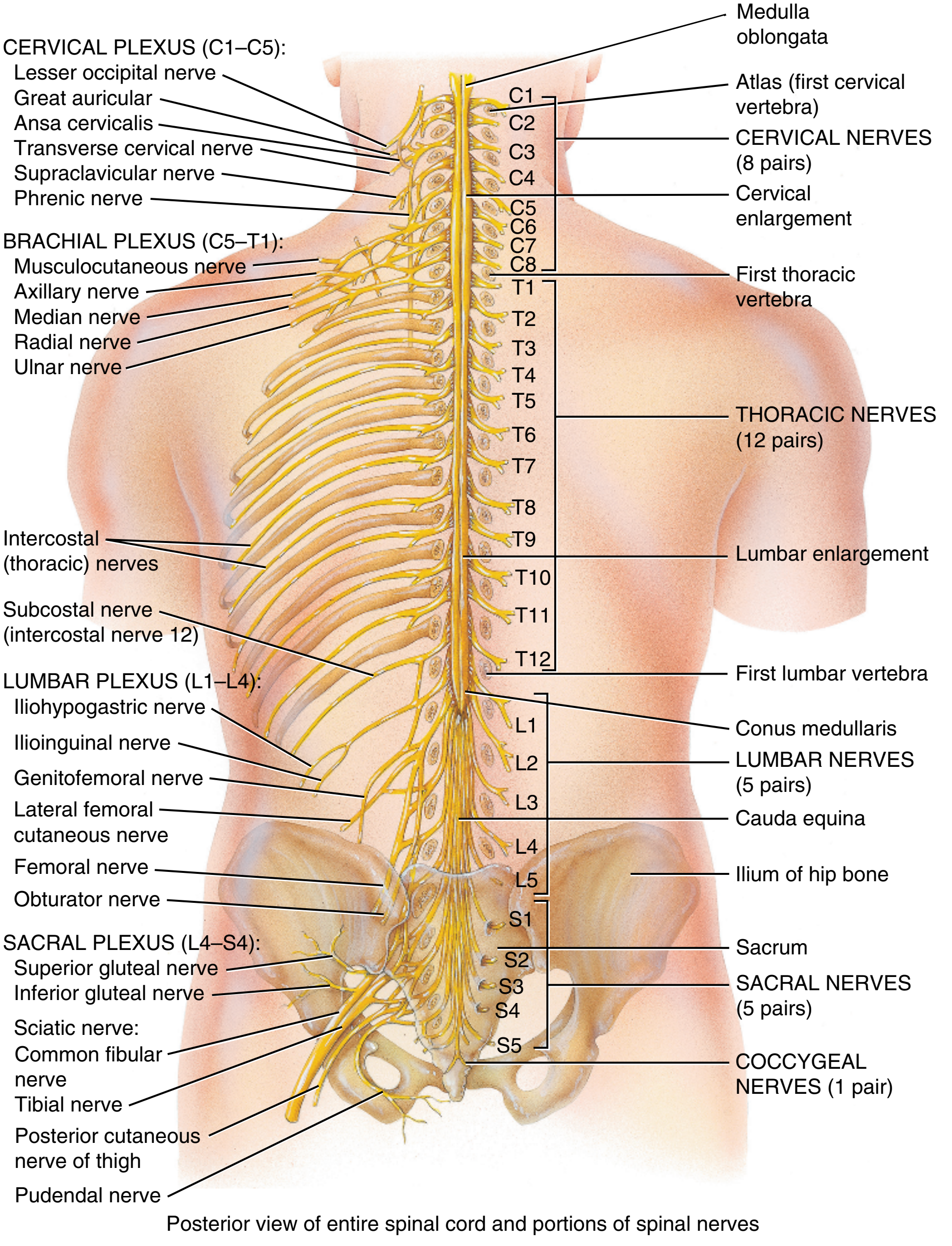

FIGURE 1.14 The spinal cord and spinal nerves

SYMPATHETIC DIVISION

The sympathetic division (see Figure 1.15) includes nerve fibres that arise from the 12 thoracic and first two lumbar segments of the spine; hence, it is also referred to as the thoracolumbar division. The sympathetic division takes control of many internal organs when a stressful situation occurs. This can take the form of physical stress if undertaking strenuous exercise or emotional stress at times of anger or anxiety. In emergency situations, the sympathetic nervous system releases norepinephrine, which assists in the 'fight or flight' response (McErlean and Migliozzi 2020).

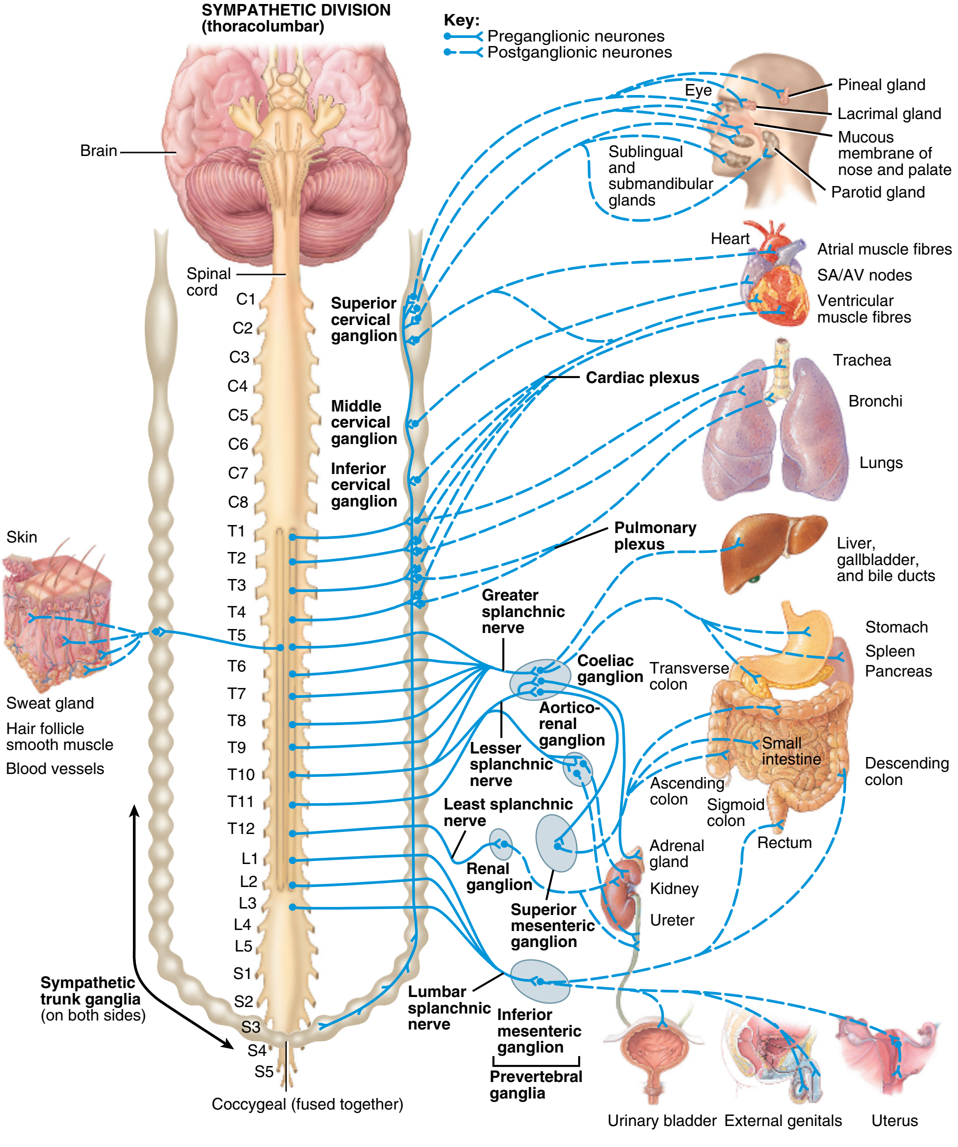

FIGURE 1.15 Sympathetic nervous system

PARASYMPATHETIC DIVISION

The parasympathetic division includes fibres arising from the lower end of the spinal cord and several cranial nerves; hence, it is often referred to as the craniosacral division. The parasympathetic division is most active when the body is at rest; it uses acetylcholine to control all the internal responses associated with a state of relaxation (Figure 1.16) and, therefore, has many opposite effects on the body to the sympathetic nervous system (Marieb and Hoehn 2019).

Table 1.2 provides a summary of the physiological effects of the sympathetic and parasympathetic divisions of the nervous system.

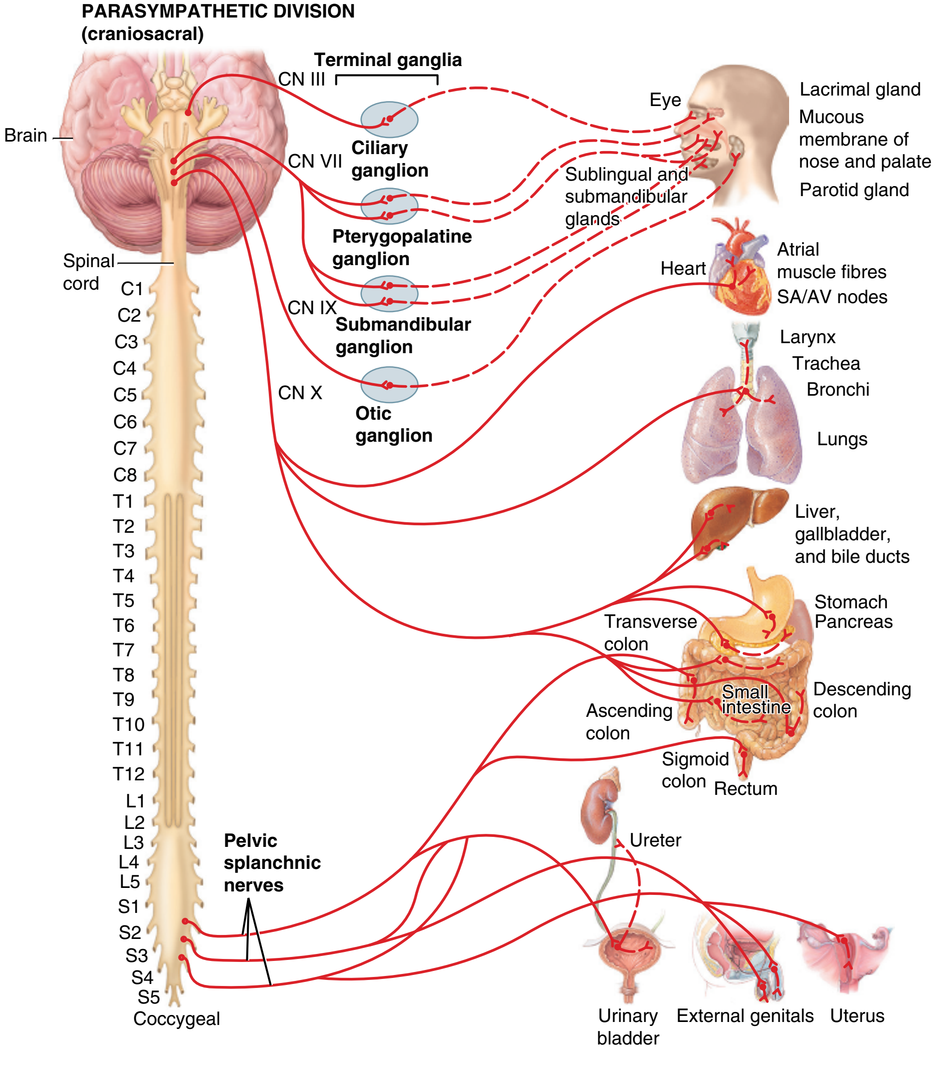

FIGURE 1.16 Parasympathetic nervous system

Table 1.2 Effects of the parasympathetic and sympathetic divisions of the autonomic nervous system

Organ/system	Sympathetic effects	Parasympathetic effects
Cell metabolism	Increases metabolic rate, stimulates fat breakdown and increases blood glucose levels	No effect
Blood vessels	Constricts blood vessels in the viscera and skin	
	Dilates blood vessels in the heart and skeletal muscle	No effect
Eye	Dilates pupils	Constricts pupils
Heart	Increases rate and force of contraction	Decreases rate
Lungs	Dilates bronchioles	Constricts bronchioles
Kidneys	Decreases urine output	No effect
Liver	Causes the release of glucose	No effect
Digestive system	Decreases peristalsis and constricts digestive system sphincters	Increases peristalsis and dilates digestive system sphincters
Adrenal medulla	Stimulates cells to secrete epinephrine and norepinephrine	No effect
Lacrimal glands	Inhibits the production of tears	Increases the production of tears
Salivary glands	Inhibits the production of saliva	Increases the production of saliva
Sweat glands	Stimulates to produce perspiration	No effect

CONCLUSION

The nervous system is a complex network that controls and coordinates the body's functions. It can be broadly divided into two main parts: the central nervous system and the peripheral nervous system.

The study of the nervous system is paramount as it forms the foundation for understanding the intricacies of human physiology and the coordination of bodily functions. This chapter has provided an overview, introducing key concepts such as the structure and function of neurones, the organisation of the central and peripheral nervous systems and the crucial role of neurotransmitters in intercellular communication.

A solid grasp of the nervous system is key for understanding various health conditions and their corresponding care interventions. From the reflex arcs that govern rapid, involuntary responses to the complexities of higher cognitive functions that are mediated by the cerebral cortex, the nervous system is a vast and interconnected network that influences every aspect of human health.

Developing a deeper understanding of neurological disorders, diagnostic assessments and care interventions is reliant upon confidently and competently understanding the anatomy and physiology of this complex system. Whether caring for patients with neurological injuries or neurodegenerative diseases, a robust comprehension of the nervous system is indispensable. By recognising the interconnectedness of the nervous system with other physiological systems, readers are better equipped to provide holistic and patient-centred care, fostering optimal health outcomes for individuals across the lifespan.

GLOSSARY OF TERMS

Action potential: A rapid change in the membrane potential of a neurone, resulting in the transmission of an electrical signal.

Central nervous system: The brain and spinal cord, responsible for processing and integrating information.

Cerebellum: The part of the brain responsible for coordination and balance.

Cerebral cortex: The outer layer of the brain involved in higher cognitive functions such as thinking, perception and language.

Cerebrospinal fluid: A clear, protective fluid that surrounds the brain and spinal cord.

Cranial nerves: Twelve pairs of nerves that arise directly from the brain and control various functions, including sensation and movement of the head and neck.

Dendrites: Branch-like extensions of a neurone that receive signals from other neurones.

Effector organs: Muscles or glands that respond to signals from the nervous system.

Medulla oblongata: The lower part of the brainstem, responsible for vital functions such as breathing and heart rate.

Neurone: The basic functional unit of the nervous system, responsible for transmitting information as electrical signals.

Neurotransmitter: Chemical substances that transmit signals between neurones at synapses.

Peripheral nervous system: Nerves and ganglia outside the central nervous system, including sensory and motor neurone.

Pons: Part of the brainstem involved in functions such as breathing and sleep.

Sensory neurones: Neurones that transmit signals from sensory organs to the central nervous system.

Spinal cord: A long, tubular structure that extends from the brainstem and serves as a pathway for nerve impulses between the brain and the body.

Vagus nerve: The tenth cranial nerve that plays a key role in regulating many bodily functions, including heart rate and digestion.

MULTIPLE CHOICE QUESTIONS

1. What is the primary function of the nervous system?
   a) Oxygen transport
   b) Digestion
   c) Communication and control
   d) Filtration

2. Which part of the nervous system is responsible for involuntary functions such as heart rate and breathing?
   a) Central nervous system
   b) Peripheral nervous system
   c) Autonomic nervous system
   d) Somatic nervous system

3. The cerebellum is primarily involved in:
   a) Vision
   b) Coordination and balance
   c) Memory
   d) Speech production

4. What is the role of dendrites in a neurone?
   a) Transmit signals away from the body cell
   b) Receive signals from other neurones
   c) Store neurotransmitters
   d) Produce myelin

5. What is the medulla oblongata responsible for?
   a) Vision processing
   b) Coordination of muscle movements
   c) Vital functions such as breathing and heart rate
   d) Emotional processing

6. Which part of the brain is associated with higher cognitive functions, such as thinking and language?
   a) Medulla oblongata
   b) Cerebellum
   c) Cerebral cortex
   d) Thalamus

7. How many pairs of cranial nerves are there?
   a) 6
   b) 8
   c) 10
   d) 12

8. What is the main function of the spinal cord?
   a) Breathing control
   b) Coordination of movement
   c) Transmitting signals between the brain and the body
   d) Vision processing

9. Which neurotransmitter is associated with mood regulation and is often targeted in the treatment of depression?
   a) Dopamine
   b) Serotonin
   c) Acetylcholine
   d) GABA

10. What is the term for the rapid change in the membrane potential of a neurone that allows for signal transmission?
a) Synapse
b) Resting potential
c) Action potential
d) Refractory period

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